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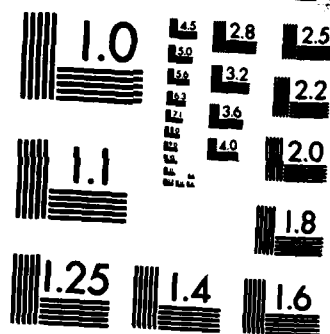UNCLASSIFIED   LIDS-FR-1449 N00014-83-K-0185   F/G 5/1   NL

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LABORATORY FOR
INFORMATION AND DECISION SYSTEMS

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AD-A152 919

OSP Number 93495

LIDS-FR-1449

FINAL REPORT

covering the period

1 March 1983 – 28 February 1985

for

ORGANIZATIONAL STRUCTURES IN C³ SYSTEMS

Contract Number N00014-83-K-0185(NR 274-349)
Expiration Date: 28 February 1985

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April 5, 1985

SERVOMECHANISMS LABORATORY
1939-1959
ELECTRONIC SYSTEMS LABORATORY
1959-1978

ORGANIZATIONAL STRUCTURES IN C³ SYSTEMS

I. PROJECT OBJECTIVES

The long range objective of this project is the development of a methodology for assessing the effectiveness of naval organizational structures supported by command, control and communications systems. The specific research was motivated by the need to relax certain assumptions so that a theory currently under development for the design and evaluation of C³ systems could be applied to more realistic organizational structures.

The research effort was organized into three tasks.

II. PROJECT TASKS

TASK 1: <u>Qualitative Differences in the Tasks of an Organization</u>

The main objective in this task was the introduction of the decisionmaker's perception of the tasks to be performed by the organization and the effect his perception has on the overall organization's performance. The analytical framework of information theory, extended to include weighted entropy, was to be used to study the effects training and common task perception have in the performance of an organization.

TASK 2: <u>Asynchronous Protocols for Information Processing in Organizations</u>

The ability to express analytically complex protocols that are used in multi-person decentralized information processing and decisionmaking organizations is a major step in extending the applicability of the theory. Furthermore, asynchronous and data-driven protocols are more realistic models of the way information flows and decisions are made within organizations. Data flow concepts were to be investigated as a formal method for modeling interactions between organization members.

TASK 3: <u>Effectiveness Analysis of C³ System Designs</u>

In order to apply the system effectiveness methodology to realistic naval organizations, several basic and applied

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research questions must be addressed. Primitives and attributes that characterize not only the physical C^3 system, but the organization together with its C^3 system must be defined and expressed in terms of measurable system quantities and mission specifications. The higher level attributes must include many of the "measures of effectiveness" that have been discussed extensively in the C^3 literature.

III. RESULTS

Task 1: The analytical framework of n-dimensional information theory has been extended to include the concept of weighted entropy. Two problems have been defined and explored. The first one addresses the case when the designer and the decisionmaker have different perceptions of the uncertainty associated with the tasks that the decisionmaker is to perform. The effect on performance and on the workload was expressed in terms of weighted entropy. The second problem that has been formulated addresses the case when the designer and the decisionmaker assign different priorities or weights to the tasks to be performed. The effect on the workload-performance locus has been analyzed and several cases of interest have been identified. Numerical simulation results for two three-person organizations, one hierarchical and one parallel, were obtained. The results were documented in a technical memorandum. The large computational effort required to obtain simulation results has redirected to task toward the development of efficient algorithms that take advantage of specific problem strutures.

Task 2: The literature of Petri Nets was reviewed first in order to develop the necessary formalism for modeling asynchronous protocols. It was determined that a new element needed to be introduced, the decision switch (or demultiplexer), that assigns the incoming task to different algorithms according to a rule or strategy u. This element has been introduced, defined formally, and used to model the interacting decisionmaker and small organizations. Then analytical schemes for defining the interactions between decisionmakers and for computing the time delay associated with various protocols were developed and an algorithm for determining expected delay was implemented.

Task 3: The methodology of system effectiveness analysis was extended in a singificant way. A new partial measure of effectiveness has been introduced that compares the time necessary to accomplish a task (from detection to the

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implementation of the selected response) with the time available, i.e., the window of opportunity determined by the mission. It was determined that timeliness cannot be expressed, in general, by a single attribute such as the window of opportunity. It depends also on where the window occurs because different options are available at different times.

The second part of this task, the consideration of an organization along with its supporting C^3 system, was addressed by modeling and analyzing three person organizations with data bases for information storage and access. Both centralized and decentralized data bases were considered. The results of this work have been documented in the M.S. Thesis by G. Bejjani.

IV. DOCUMENTATION

The results of these research efforts were presented at the 6th and 7th MIT/ONR Workshops on C^3 Systems, more recent results will be presented at the 8th MIT/ONR Workshop.

A. Published Papers

A.1 D. A. Stabile and A. H. Levis, "The design of information structures: Basic allocation strategies for organizations," Large Scale Systems, Vol. 6, 1984, pp. 123-132.

A.2 A. H. Levis, "Information processing and decision-making organizations: A mathematical description," Large Scale Systems, Vol. 7, 1984, pp. 151-163.

B. Papers in Conference Proceedings

B.1 Same as A.1; in Proc. 6th MIT/ONR Workshop on C^3 Systems, LIDS-R-1354, Laboratory for Information and Decision Systems, MIT, December 1983.

B.2 Same as A.2; in Proc. 6th MIT/ONR Workshop on C^3 Systems, LIDS-R-1354, Laboratory for Information and Decision Systems, MIT, December 1983.

B.3 D. Tabak and A. H. Levis, "Pteri Net representation of decision models," in Proc. 7th MIR/ONR Workshop on C³ Systems, LIDS-R-1437, Laboratory for Information and Decision Systems, MIT, December 1984.

C. Theses

G. J. Bejjani, "Information Storage and Access in Decisionmaking Organizations," M.S. Thesis, Report LIDS-TH-1434, Laboratory for Information and Decision Systems, MIT, Cambridge, MA, January 1985.

V. Jin, "Delays in Decisionmaking Organizations," M.S. Thesis, Laboratory for Information and Decision Systems, MIT, Cambridge, MA (to appear in May 1985).

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